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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ELASTOMERIC RESIN COMPOSITIONS

(57) Abstract: The present invention relates to elastomeric compounds having a high filler content additionally containing 1 to 400 % by weight of resin of microsilica as a modifier to improve the processability. Thereafter, the invention relates to a method for production of elastomeric compounds having a high filler content, wherein microsilica is added to the elastomeric compounds in an amount of 1 to 400 % by weight of resin as a modifier to improve processability.

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Title of Invention

Elastomeric resin compositions.

Technical field:

- 5 The present invention relates to new and improved resin compositions and, more particularly, to elastomeric resins with high filler loads that have improved processability. The method for producing these new and improved elastomeric compositions is also disclosed. The invention further relates to elastomeric resins having improved flame retardant capability.

10 **Technical Background:**

- It is well known to produce elastomeric compounds such as those used in seals, gaskets, tyres, cables and other articles made from rubber using ingredients like fillers, plastizisers, antioxidants, curatives and others. All these compound ingredients are used to receive certain properties of the final article
- 15 or are necessary during the manufacturing. But some of these substances do influence each other leading to detrimental effects on physical properties or on processing behaviour. Functional fillers, for instance some carbon blacks and precipitated silicas, are used to improve hardness, tensile strength, tear resistance and other desired properties, but they also, especially at high filler
- 20 loadings, increase compound viscosity leading to poor processability and scorch safety. This has to be balanced out by the incorporation of plastizisers and/or process aids. Plastizisers and process aids have, however, a negative influence on physical properties, including fire performance and they can "bloom out". So far no material is known that could overcome the processing
- 25 difficulties of elastomeric resin compositions with high filler loading, and still maintaining the desired physical properties.

- It is very difficult to give a precise definition of "high filler loading" as it depends very much on the polymer used and on the application of the final compound. However, generally if the filler content of a highly filled elastomeric
- 30 compounds is increased, the viscosity will increase to a level where the processability of the compounds will be strongly reduced. The amount of fillers

in highly filled resins can thus, depending on the polymer, vary from about 15 to about 500 % by weight of resin.

It is known to use microsilica as semi-reinforcing filler in elastomers replacing for instance MT (medium thermal) -black or calcium silicate fillers. In these instances microsilica has always been used as a replacement to obtain a less costly elastomer having the same strength. Thus the total filler loading has never been increased when using microsilica as a semi-reinforcing filler.

Disclosure of Invention:

It is an object of the present invention to provide a highly filled elastomeric compound with a low viscosity to give a good processability without reducing the filler content and without negatively influencing physical properties of the elastomeric compounds. In some instances the filler content can even be increased without increasing the viscosity and without negatively influencing the physical properties. It is further an object to provide elastomeric compounds having an improved flame-retardant capability.

According to one aspect the present invention relates to elastomeric compounds having a high filler content, the elastomeric compounds being characterised in that they additionally contain 1 to 400 % by weight of resin of microsilica as a modifier to improve the processability.

According to a preferred embodiment the elastomeric compounds contain 5 to 300 % by weight of resin of microsilica.

Most preferably the elastomeric compounds contain 10 to 150 % by weight of the resin of microsilica.

According to another aspect the present invention relates to a method for production of highly filled elastomeric compounds having a high filler content, the method being characterised in that microsilica is added to the elastomeric compounds in an amount of 1 to 400 % by weight of resin to improve the processability.

According to a preferred embodiment microsilica is added to the elastomeric compounds in an amount of 5 to 300 % by weight of resin.

For best results microsilica is added to the elastomeric compounds in an amount of 10 to 150 % by weight of resin.

- 5 The term microsilica used in the specification and claims of this application is particulate amorphous SiO_2 obtained from a process in which silica (quartz) is reduced to SiO-gas and the reduction product is oxidised in vapour phase to form amorphous silica. Microsilica may contain at least 70% by weight silica (SiO_2) and has a specific density of $2.1 - 2.3 \text{ g/cm}^3$ and a surface area of 15 –
10 40 m^2/g . The primary particles are substantially spherical and have an average size of about $0.15 \mu\text{m}$. Microsilica is preferably obtained as a co-product in the production of silicon or silicon alloys in electric reduction furnaces. In these processes large quantities of microsilica are formed. The microsilica is recovered in conventional manner using baghouse filters or
15 other collection apparatus.

The present invention also relates to the use of microsilica as a modifier to improve the processability of elastomeric compounds and to the use of microsilica to improve the limiting oxygen index of flame retardant elastomeric compounds filled with aluminum trihydrate and/or magnesium hydroxide.

- 20 It has surprisingly been found that elastomeric compounds according to the present invention have a low viscosity and good processing properties compared to elastomeric compounds having the same high filler content, but do not contain microsilica. It has further been found that the addition of microsilica to elastomeric compounds having a high filler content can be used
25 in all types of crosslinking technologies and it is not decreasing the rate of crosslinking in sulphur cured compounds like other siliceous materials such as precipitated silica. For elastomeric compounds containing other silica type fillers and silane coupling agents, no increase in silane dosage for coupling purposes is necessary. Thus in addition to reaching filler loading levels not
30 possible so far, the present invention also allows savings in other compound ingredients and in processing costs due to better flow characteristics of the

elastomeric compounds. Furthermore the compression set in the highly filled elastomeric compounds is improved.

It has also surprisingly been found that in flame retardant elastomeric compounds filled with aluminium trihydrate and/or magnesium hydroxide, the addition of microsilica to such elastomeric compounds results in an increased limiting oxygen index (LOI) and a stable char is formed when the elastomeric compounds filled with aluminum trihydrate and/or magnesium hydroxide are burning.

The elastomeric compounds according to the invention includes compounds based on elastomers like natural rubber (NR), ethylene-propylene-diene rubber (EPM and EPDM), styrene-butadiene rubber (SBR), acrylonitrile-butadiene rubber (NBR), polychloroprene rubber (PCP), speciality polymers like acrylate rubber and ethylene vinyl acetate copolymer and others and blends thereof and also compounds based on blends of elastomers with thermoplastics, so-called thermoplastic elastomers, and to a method for the production of those polymer compositions.

The term elastomer includes not only traditional elastomeric materials like natural rubber or synthetic rubber-like polymers but also blends thereof and thermoplastic elastomers.

The manufacturing of the elastomeric compounds can be done using conventional processes and equipment like open mill, internal mixers of all types and continuous mixers like single or twin-screw extruders.

The processing of the elastomeric compounds containing the modifier can be done using conventional methods, including but not restricted to extrusion, compression moulding, injection moulding and others.

Detailed description of the invention

Example 1

30 parts per 100 parts resin (phr) of microsilica was added to a formulation based on EPDM rubber containing 140phr calcined clay together with

antioxidants, plastiziser and a peroxide cure system. The mixing of the compound was carried out in an internal mixer and the samples for the tests were press-cured at 180°C for 20 minutes. The results obtained are shown in Table 1. For comparison purposes the EPDM rubber without microsilica was tested in the same way as the compound according to the invention. The tests were performed according to the following specifications: Tensile test: S2 DIN 53504, tear resistance (trouser tear) BS 6469.

Table 1

	Prior Art	Invention
Measured property	EPDM rubber with 140phr calcined clay filler	EPDM rubber with 140 phr calcined clay filler and 30phr microsilica
Mooney viscosity @ 130°C	45	47
Tensile strength, MPa	7.8	8.4
Elongation at break, %	283	276
Tear resistance, N/mm	2.0	2.8
Compression set (10min @200°C) in %	16.6	16.8

The results in Table 1 demonstrate that the EPDM rubber according to the invention has improved physical properties, especially a remarkable low compression set at this high filler level, together with the good processability, expressed by the viscosity value, compared to the EPDM rubber without microsilica.

Example 2

A compound based on chloroprene rubber was prepared with 50 phr-precipitated silica having a surface area of 125m²/g. To the same compound, 20 phr of the precipitated silica was replaced with 30 phr of microsilica. The mixing of the compounds was carried out as described in Example 1. The specimens for physical tests were press-cured at 180°C for 15 minutes. As can be seen from the results in Table 2 it was surprisingly found that the replacement of precipitated silica with microsilica decreases the compound

viscosity leading to better processability while maintaining a high level of physical properties.

Table 2

Measured Property	Prior Art	Invention
	Chloroprene rubber with 50phr precipitated silica	Chloroprene rubber with 30phr precipitated silica + 30phr microsilica
Mooney viscosity @ 120°C	41.0	25.7
Tensile strength, MPa	17.6	18.1
Elongation at break, %	742	754
Tear resistance, N/mm	12.2	9.3

Example 3

A compound based on solution SBR and filled with 80phr highly dispersible precipitated silica having a surface area of $175\text{m}^2/\text{g}$ was modified by adding 20phr microsilica. For comparison purposes a mix containing 100phr of the precipitated silica was also prepared. A three step mixing procedure was used for compounding. The curing of the specimens for physical tests was carried out at 160°C for 20 minutes.

The results are shown in Table 3. The abrasion was measured according to DIN 53516.

Table 3

	Prior Art	Prior	Invention
Measured property	SBR containing 80phr precipitated silica	SBR containing 100phr precipitated silica	SBR containing 80phr precipitated silica + 20phr microsilica
Mooney viscosity @ 100°C	82	117	87
Tensile strength, MPa	21.5	20.0	19.5
Elongation at break, %	447	402	383
Tear resistance, N/mm	17.1	17.9	22.1
Shore A Hardness	69	79	72
Abrasion, mm ³	145	175	157

Comparing these results the amazing effect of microsilica on compound properties at high filler loading is obvious. Not only that higher filler loading is possible without processing problems, but there is also an improvement in physical properties not achievable with conventional precipitated silica.

Example 4

In a NBR/PVC compound filled with a mix of carbon black N550, calcium carbonate and precipitated silica the total filler content was 110phr. This compound was modified by addition of 20phr microsilica. The mixing was carried out as described in example 1. The test specimens were press-cured at 180°C for 15 minutes. The results are shown in Table 4

Table 4

Measured property	Prior Art	Invention
	NBR/PVC with 28phr precipitated silica	NBR/PVC with 20phr precipitated silica + 20phr microsilica
Mooney viscosity @ 120°C	58	42
Tensile strength, MPa	12.1	13.4
Elongation at break, %	350	377
Tear resistance, N/mm	5.8	4.7
Oil resistance 24h @ 100°C in ASTM-oil No. 2		
Tensile strength, MPa	13,1	13.9
Elongation at break, %	307	321

5 The results in Table 4 show that the NBR/PVC compound according to the invention has a lower viscosity than the prior art compound although it contains 12phr more of filler. The results for oil resistance further show that the NBR/PVC compound containing microsilica maintains its tensile strength and elongation when the compound is subjected to oil at high temperature.

Example 5

10 To a compound based on natural rubber (SIR 20) and filled with 50phr carbon black (N234), 50phr of microsilica was added. For comparison purposes also compounds containing 100phr N234 (Comparison 1) and 50phr N234 + 50phr precipitated silica (Comparison 2), respectively, were prepared. The mixing was carried out in an internal mixer using a two-step cycle similar to example

15 1. The silica and silane containing compounds were mixed using a standard three-step procedure as in example 3. The test specimens were press-cured for 15 minutes at 150°C. The results are summarised in Table 5.

Table 5

	Prior Art	Comp. 1	Comp. 2	Invention
Measured property	SIR 20 with 50phr carbon black N234	SIR 20 with 100phr carbon black N234	SIR 20 with 50phr carbon black N234 + 50phr precipitated silica	SIR 20 with 50phr carbon black N234 + 50phr microsilica
Mooney viscosity @ 100°C	58.7	Not measurable, >220	106.5	55.4
Tensile strength, MPa	29.0	18.2	13.8	21.8
Elongation at break, %	576	221	344	441
Hardness, Shore A	63	88	71	73
Tear resistance, N/mm	18.6	15.7	4.1	23.9

From the results in Table 5 it is obvious that the addition of microsilica allows
 5 the preparation of compounds not possible with conventional materials.

One has to keep in mind that no optimisation of compound formulation was carried out in the examples listed above. This means that further improvement of the properties is possible when additional re-formulation of the recipes are done.

The above examples 1 – 5 clearly show that the addition of microsilica to highly filled elastomeric compounds improves the physical properties of the materials while maintaining and even lowering the viscosity of the compounds.

Example 6

- 5 This examples illustrates the effect on microsilica addition on fire performance of elastomeric resin compositions.

To a halogen-free, flame retardant compound based on ethylene vinyl acetate (100phr) and filled with 160 phr aluminium trihydrate, 30 phr of microsilica were added. The mechanical properties of the compound were not effected.

- 10 The limiting oxygen index. measured according to ASTM D2863 was increased from 38 to 43 %. The stability of the protective char, formed during the burning of the polymer matrix, was significantly improved and withstand three to four times longer than without microsilica addition.

CLAIMS:

1. Elastomeric compounds having a high filler content,
5 characterized in that they additionally contain 1 to 400 % by weight of resin of microsilica as a modifier to improve the processability.
2. Elastomeric compounds according to claim 1, characterized in that they contain 5 to 300 % by weight of resin of microsilica.
3. Elastomeric compounds according to claim 2, characterized
10 in that they contain 10 to 150 % by weight of resin of microsilica.
4. A method for production of elastomeric compounds having a high filler content, characterized in that microsilica is added to the elastomeric compounds in an amount of 1 to 400 % by weight of resin as a modifier to improve processability.
- 15 5. Method according to claims 4, characterized in that microsilica is added to the elastomeric compounds in an amount of 5 to 300 % by weight of resin.
6. Method according to claim 5, characterized in that
20 microsilica is added to the elastomeric compounds in an amount of 10 to 150 % by weight of resin.
7. Use of microsilica as a modifier to improve processability of highly filled elastomeric compounds.
8. Use of microsilica as a modifier to increase the limiting oxygen index of flame-retardant elastomeric compounds filled with aluminum trihydrate and/or
25 magnesium hydroxide.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO 03/00166

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C08K 3/34, C08K 3/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C08K, C08L, C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	claims 1-7	8
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☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 03/00166

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

26/07/03

International application No.

PCT/NO 03/00166

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